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Learning Classifiers for Science Event Detection in Remote Sensing Imagery

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We describe a classifier, currently running onboard the EO-1 spacecraft, used to detect cryosphere events in hyperspectral image data. The results are used by the Autonomous Sciencecraft Experiment (ASE) of NASA's New Millennium Program onboard EO-1 to automatically target the spacecraft to collect follow-on imagery. Historically, data collected by a spacecraft is downlinked to Earth and pre-processed before any analysis is performed. With manual on the ground analysis in the control loop, it can take days or weeks to identify and have the spacecraft respond to events. Onboard analysis enables rapid reaction to dynamic events, such as flooding, volcanic eruptions or sea ice break-up with current response times on the order of hours. Future missions may be able to respond in seconds. Our software demonstrates the potential for future deep space missions to make decisions onboard and capture short-lived science events. Onboard data analysis and event detection can also be used to identify high priority data for downlink to Earth, providing a method for maximizing the use of a potentially bandwidth limited downlink channel.

We developed four pixel-based classifiers to identify cryosphere events using hyperspectral images. These classifiers include a manually constructed classifier, a Support Vector Machine (SVM), a Decision Tree and a classifier derived by searching exhaustively over combinations of thresholded band ratios. Each of the classifiers was designed to run in the computationally constrained operating environment of the spacecraft. For example, while the Hyperion instrument on EO-1 has 220 bands, only 12 can be accessed onboard. We labeled a set of scenes by hand to provide training and testing data. Performance results on the test data indicate that the SVM and manual classifiers outperformed the Decision Tree and band-ratio classifiers with the SVM yielding slightly better classifications than the manual classifier. As a result of this performance evaluation, mission scientists have selected the SVM as the operational classifier for the remainder of the mission.